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CO_2 LASER MICROMANIPULATOR PARALLAX ERROR RESOLVED

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ABSTRACT

Most current CO_2 laser micromanipulators for microlaryngoscopy experience the parallax aiming problem. This occurs when the beam mirror is offset below the optical path for the microscope, making use of the laser difficult through small laryngoscopes or in pediatric patients. The newer "hot mirror technology" micromanipulators that are now available overcome this problem.

In addition to providing a laser beam coincident with the optical path, the newer units offer much smaller spot sizes (250-micron diameter at 400-mm focal length), but all partially absorb some of the light available for illumination. To quantitate this, optical absorption spectra were determined for five "hot mirrors". Clinical experience with more than 100 cases has demonstrated the advantages of these new mirrors to minimize mucosal thermal damage and give improved exposure for subglottic and pediatric laryngoscopy.

Key Words: CO_2 laser, micromanipulator, parallax

INTRODUCTION

The carbon dioxide laser has been used for endolaryngeal procedures since the early 1970's when Jako demonstrated the safety and effectiveness of this tool on dogs[1]. The micromanipulators for these early lasers had a much larger minimum spot size compared with the standard microscope micromanipulator that is currently available. Originally, the minimum spot size was approximately 1 mm in diameter. The second generation micromanipulators used with carbon dioxide lasers had a spot size of approximately 800 microns, and the newest generation of which this report is concerned,have minimum spot sizes on the order of 250 microns.

As a consequence of engineering limitations involved with the diameter of the raw beam from the laser, the beam path of these early micromanipulators was offset below the optical path link in the microscope. This resulted in frequent instances where the CO_2 beam impacted on the rim of the laryngoscope or, worse yet, on the lip of the patient, as the beam originated from below the optical path and traveled upward to meet the optical path at a distance of 400 mm. The mirror was offset in order to provide a large enough reflecting surface for the CO_2

beam without impending on the medial field of view through the microscope.

The newest generation of micromanipulators employ a "hot mirror" that allows the carbon dioxide beam to be directed coincident with the optical path, eliminating this problem. It has been noted that each of these hot mirrors subjectively degraded the optical spectrum and altered the color balance of the target tissues.

In order to more fully evaluate the problems with the early micromanipulators this study was undertaken to measure the extreme of the parallax problem in representative early micromanipulators and to characterize the optical characteristics of these "hot mirrors".

THE PARALLAX PROBLEM

Carbon dioxide laser micromanipulators without a "hot mirror" use a front surfaced mirror to redirect the carbon dioxide and aiming beams down the laryngoscope. This front surfaced mirror is reflective for both the carbon dioxide wavelength as well as the 632 mm wavelength of the helium neon aiming beam. The diameter of the raw beam emerging from the lens assembly on the micromanipulator is of a size that would require the front surfaced mirror to be larger than would be allowed to fit between the independent optical paths for each eye (at the objective lens

level of the microscope). If the mirror were situated in this position, a significant limitation to the nasal field of view would be encountered for each eye. To overcome this limitation, the front surfaced mirrors are mounted below the optical path length (Figure 1). In some laser micromanipulators the front surface mirror is mounted as much as 1 cm or more below the optical path length (Sharplan 719 M).

Difficulties arise when using pediatric laryngoscopes, or when using laryngoscopes or subglottiscopes with limited vertical opening heights. The proximal opening available on pediatric laryngoscopes and some subglottiscopes often is as small as 1 cm in vertical height, due to anatomic limitations.

A situation then results where the surgeon may be able to see the target at a distance of 400 mm from the objective lens, but the carbon dioxide laser beam directed up from below the optical path length then impacts on the rim of the laryngoscope (Arrow, Figure 1). Anecdotal cases have been related to the two senior authors (RHO and JW) where inadvertent burns of the patient's upper lip have occurred when this problem has not been recognized.

This parallax error (the variation between the optical path and the laser beam path) has limited the potential applications of the carbon dioxide laser for some pediatric and subglottic applications. This parallax

error problem was resolved by the development of the "hot mirror technology", which employs a lens placed in the optical path itself. Through the development of proprietary dichroic coatings these lenses are capable of reflecting the carbon dioxide laser beam (and in some cases the helium neon beam as well) coincident with the optical path down the laryngoscope (Figure 2). This results in the surgeon visualizing the target directly and may be described as "if you can see it you can hit it" which was not the case with the early micromanipulators.

Coherent Medical (Palo Alto, California) was one of the first companies to employ this hot mirror technology in a standard micromanipulator. This micromanipulator still had a spot size of 800 microns at 400 mm focal length but was the first parallax free micromanipulator available. Since the development of this micromanipulator, advances in engineering and technology have allowed the development of other hot mirror micromanipulators with much smaller spot sizes (i.e. the new generation microspot micromanipulators). These newer hot mirror micromanipulators are capable of producing spot sizes of 300 to 250 microns in diameter at 400 mm focal length. It has been noted by most surgeons operating with hot mirrors that there is a subjective decrease in the available light that is reflected back to the surgeon through these lenses and that there is also a subtle subjective

alteration in color balance. This is due to the dichroic coatings that are employed on the hot mirrors. To quantitate this optical degradation, the optical characteristics of each of the hot mirrors commercially available was performed.

MATERIALS AND METHODS

The hot mirror lens assemblies from four different manufacturers were obtained for testing. A prototype hot mirror as well as a production hot mirror was obtained from Sharplan Lasers, Inc. (Allendale, New Jersey). Hot mirrors were also tested from Coherent Medical (Palo Alto, California), Heraeus LaserSonics, Inc. (Milpitas, California), and I.L. Med, Inc. (Walpole, Massachusetts).

A Hewlett Packard 8452A diode array UV-visible spectrophotometer was used for all testing. The hot mirrors were compared to an air reference standard. Optical spectra were obtained between 400 nm wavelength (near UV) to 700 nm wavelength (near infrared).

RESULTS

The optical spectra for each of the five hot mirrors tested is represented in figure 3. Absorbance is defined as the logarithmic ratio of incident light to transmitted light. From the graphs it can be seen that all

hot mirrors reduce the available light by a smaller factor in the middle of the spectrum than at either extremes. Also, since the optical spectrum is not flat, this implies that the subjective color balance that the surgeon would view when looking through the hot mirrors would not be identical to normal vision.

The prototype Sharplan hot mirror demonstrated a significant absorption when compared to the production version of the mirror. The Coherent and I.L. Med hot mirrors have identical spectra with fairly low optical absorbance. All of the mirrors partially absorb some of the available light.

DISCUSSION

There are some subtle differences between the hot mirrors from each corporation. The Heraeus hot mirror assembly was the first on the market and does not use a helium neon aiming beam. Instead, the Heraeus unit uses a virtual image aiming dot that is provided by a light emitting diode that must be aligned with the CO_2 beam in a test firing procedure prior to use on the patient[2,3]. The Sharplan hot mirror assembly uses a unique coating which not only reflects the carbon dioxide wavelengths but also reflects the 632 wavelength of the helium neon aiming beam as well[4]. The Coherent and I.L. Med units both utilize a very small mirror in

the center of the optical assembly to reflect the helium neon beam while the remainder of the assembly contains the coating for the carbon dioxide beam.

The Heraeus hot mirror assembly is capable of producing microspot sizes on the order of 300 microns in diameter while the others have produced spot sizes of 250 microns in diameter[2-4]. These small spot sizes are not the result of the hot mirror assembly alone, in fact the hot mirror assembly does not contain any focusing apparatus as such. Rather, the lens assemblies that are mounted above the hot mirror focus the carbon dioxide beam which is merely reflected off the mirror assembly to its final small spot size. It should be noted that the I.L. Med unit uses a unique approach to achieving its small spot size by mounting the laser itself within close proximity to the lenses and mirror. This is in contrast to each of the other units in which an articulated arm assembly is used to redirect the beam from the laser to the micromanipulator.

Prototype or working models of the microspot micromanipulators with the hot mirror assemblies have been used at our institution for over 2 years. To date, over 100 cases have been completed using these micro spot micromanipulators. While in the past it was difficult and frequently impossible to obtain adequate exposure for laser applications in the subglottis, or to perform pediatric microlaryngoscopy with the CO_2 laser,

it is now a routine part of our practice. The absence of the parallax problem encountered with previous micromanipulators combined with the small spot sizes has enabled the carbon dioxide laser to be applied to smaller patients and more limited surgical exposures. Pediatric and adult subglottic stenoses have been treated with sequential micro-trapdoor flaps, and the necessity of an open laryngotracheoplasty has been avoided[4]. We believe this technology to be the new standard of care for most of our microlaryngeal carbon dioxide laser applications.

CONCLUSION

Previous micromanipulators had unfortunate problems with alignment that allowed the CO_2 beam to impact on the rim of the laryngoscope or on the patient due to beam offset from the optical path. The new generation of micro spot micromanipulators with hot mirror technology has solved the parallax problem of exposure to the distal subglottis in adults, and for the larynx in pediatric patients. The newer micromanipulators have been in use now for over 2 years and in greater than 100 patients and have been found to be an absolute necessity for the performance of certain procedures. We believe these new units to be the new standard of instrumentation for use in endoscopic microlaryngeal cases.

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REFERENCES

1. Jako GJ: Laser Surgery of the vocal cords. Laryngoscope 1972;82:2204-2216.

2. Shapshay SM, Wallace RA, Kveton JF, Hybels RL, Setzer SE: New microspot micromanipulator for CO_2 laser applications in otolaryngology-head and neck surgery. Otolaryngol Head Neck Surg 1988;98:179-181.

3. Shapshay SM, Wallace RA, Kveton JF, Hybels RL, Bohigian RK, Setzer SE: New microspot micromanipulator for carbon dioxide laser surgery in otolaryngology. Arch Otolaryngol Head Neck Surg 1988;114:1012-1015.

4. Ossoff RH, Werkhaven JA, Rafe J, Abraham M: Advanced microspot microslad for the CO_2 laser. Otolaryngol Head Neck Surg 1991;105:411-414.

LEGENDS

Figure 1. Micromanipulator with parallax error. Laser beam is offset below the optical path. Note potential impact of laser beam with rim of laryngoscope or patient's lip (arrow).

Figure 2. Micromanipulator with "hot mirror" lens. Laser beam path is coincident with optical path.

Figure 3. UV-visible absorbance spectra for the prototype (S_1) and production (S_2) Sharplan, Coherent ,I.L. Med and Heraeus mirrors.